

WHAT IS CLAIMED IS:

1. A method for selective removal of a high-k material from a substrate, the method comprising:

providing a high-k material on a semiconductor substrate; and

contacting the high-k material with a solution comprising HF, an organic compound, and an inorganic acid other than HF, whereby the high-k material is selectively removed from the substrate.

2. The method according to claim 1, wherein the high-k material has a dielectric constant of greater than or equal to about 7.

3. The method according to claim 1, wherein the high-k material is selected from the group consisting of  $ZrO_2$ ,  $Al_2O_3$ ,  $HfO_2$ ,  $Zr_{1-x}Al_xO_y$ ,  $HfSiO_x$ ,  $HfAlO_x$ ,  $HfSiO_xN$ , and combinations thereof, wherein x is an integer, and wherein y is an integer.

4. The method according to claim 1, wherein a concentration of HF in the solution is less than or equal to about 0.2 M.

5. The method according to claim 1, wherein a concentration of HF in the solution is from about 0.005 M to about 0.1 M.

6. The method according to claim 1, wherein a concentration of HF in the solution is about 0.05 M.

7. The method according to claim 1, wherein the inorganic acid is selected from the group consisting of HCl,  $HNO_3$ ,  $H_2SO_4$ ,  $H_3PO_4$ , and mixtures thereof.

8. The method according to claim 1, wherein a concentration of the inorganic acid in the solution is less than or equal to about 50%.

9. The method according to claim 1, wherein a concentration of the inorganic acid in the solution is from about 10% to about 30%.

10. The method according to claim 1, wherein a concentration of the inorganic acid in the solution is about 20%.

11. The method according to claim 1, wherein a wettability of the organic compound for the high-k material is higher than a wettability of the organic compound for silicon oxide.

12. The method according to claim 1, wherein the organic compound is selected from the group consisting of an alcohol, acetone, a polar solvent, and mixtures thereof.

13. The method according to claim 1, wherein the organic compound is selected from the group consisting of ethanol, isopropylalcohol, ethyleneglycol, and mixtures thereof.

14. The method according to claim 1, wherein a concentration of the organic compound in the solution is greater than or equal to about 50%.

15. The method according to claim 1, wherein a concentration of the organic compound in the solution is from about 60% to about 90%.

16. The method according to claim 1, wherein a concentration of the organic compound in the solution is about 80%.

17. The method according to claim 1, wherein a temperature of the solution is from about 20°C to about 80°C.

18. The method according to claim 1, wherein a temperature of the solution is about 40°C.

19. The method according to claim 1, wherein the solution comprises HF, HCl, and ethanol.

20. The method according to claim 1, wherein the solution comprises about 0.05 M HF, about 20% HCl, and about 80% ethanol.

21. The method according to claim 1, wherein the solution further comprises a surfactant.

22. The method according to claim 1, wherein the solution has a pH of from about -0.5 to about 2.

23. A method for selective removal of a high-k material from a semiconductor substrate comprising:

providing a high-k material on a semiconductor substrate;

subjecting the high-k material to damaging, whereby a damaged high-k material is obtained; and thereafter

contacting the damaged high-k material with a solution comprising HF, an organic compound, and an inorganic acid other than HF, whereby the high-k material is selectively removed from the substrate.

24. The method according to claim 23, wherein the high-k material has a dielectric constant of greater than or equal to about 7.

25. The method according to claim 23, wherein the high-k material is selected from the group consisting of  $\text{ZrO}_2$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{HfO}_2$ ,  $\text{Zr}_{1-x}\text{Al}_x\text{O}_y$ ,  $\text{HfSiO}_x$ ,  $\text{HfAlO}_x$ ,  $\text{HfSiO}_x\text{N}$ , and combinations thereof, wherein x is an integer, and wherein y is an integer.

26. The method according to claim 23, wherein a concentration of HF in the solution is less than or equal to about 0.2 M.

27. The method according to claim 23, wherein a concentration of HF in the solution is from about 0.005 M to about 0.1 M.

28. The method according to claim 23, wherein a concentration of HF in the solution is about 0.05 M.

29. The method according to claim 23, wherein the inorganic acid is selected from the group consisting of HCl,  $\text{HNO}_3$ ,  $\text{H}_2\text{SO}_4$ ,  $\text{H}_3\text{PO}_4$ , and mixtures thereof.

30. The method according to claim 23, wherein a concentration of the inorganic acid in the solution is less than or equal to about 50%.

31. The method according to claim 23, wherein a concentration of the inorganic acid in the solution is from about 10% to about 30%.

32. The method according to claim 23, wherein a concentration of the inorganic acid in the solution is about 20%.

33. The method according to claim 23, wherein a wettability of the organic compound for the high-k material is higher than a wettability of the organic compound for silicon oxide.

34. The method according to claim 23, wherein the organic compound is selected from the group consisting of an alcohol, acetone, a polar solvent, and mixtures thereof.

35. The method according to claim 23, wherein the organic compound is selected from the group consisting of ethanol, isopropylalcohol, ethyleneglycol, and mixtures thereof.

36. The method according to claim 23, wherein a concentration of the organic compound in the solution is greater than or equal to about 50%.

37. The method according to claim 23, wherein a concentration of the organic compound in the solution is from about 60% to about 90%.

38. The method according to claim 23, wherein a concentration of the organic compound in the solution is about 80%.
39. The method according to claim 23, wherein a temperature of the solution is from about 20°C to about 80°C.
40. The method according to claim 23, wherein a temperature of the solution is about 40°C.
41. The method according to claim 23, wherein the solution comprises HF, HCl, and ethanol.
42. The method according to claim 23, wherein the solution comprises about 0.05 M HF, about 20% HCl, and about 80% ethanol.
43. The method according to claim 23, wherein the solution further comprises a surfactant.
44. The method according to claim 23, wherein the solution has a pH of from about -0.5 to about 2.
45. The method according to claim 23, wherein the damaging comprises chemical damaging.
46. The method according to claim 23, wherein the damaging comprises physical damaging.